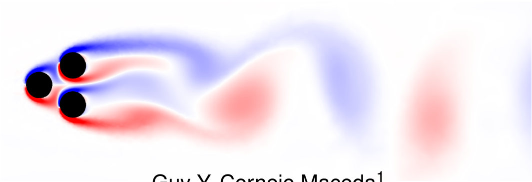
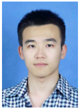
Wake stabilization with machine learning control



Guy Y. Cornejo Maceda[1]

B. R. Noack[234]	F. Lusseyran[2]	M. Morzynski[5]	L. Pastur[6]	N. Deng[6]
				

[1]LIMSI, CNRS - UPR3251 Paris-Sud University, Paris-Saclay University, France
[2]LIMSI, CNRS - UPR3251 Paris-Saclay University, France
[3]Harbin Institute of Technology, China
[4]Technische Universität Berlin, Germany
[5]Poznan University of Technology, Pologne
[6]IMSIA - UMR9219, ENSTA ParisTech, France

ASTRID-ANR-17- FLOwCON, Contrôle d'écoulements turbulents en boucle fermée par apprentissage automatique

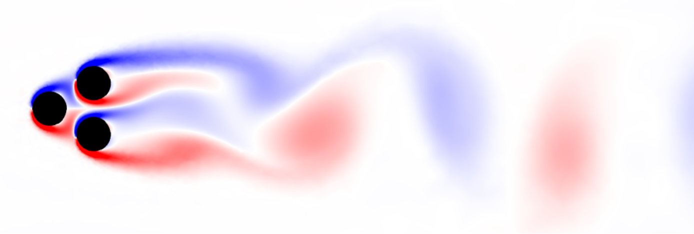
JDD, Paris, June 6^{th}, 2019

The fluidic pinball - a nonlinear system for control benchmark

ground transport

airborne transport

wind turbine



Marek Morzynski

DNS

Finite Elements Method

8633 vertices

3^{rd} *order in time and space*

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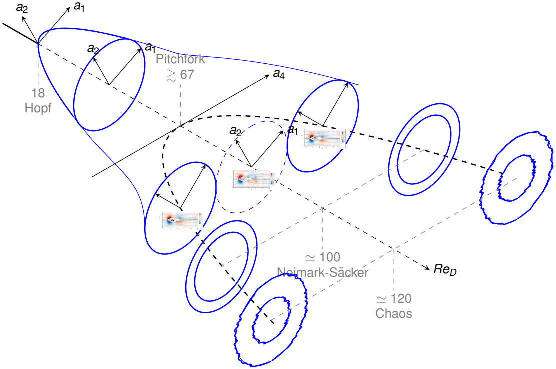

Bifurcation diagram of the fluidic pinball

Nan Deng

Luc Pastur

Deng et al.
JFM 2018

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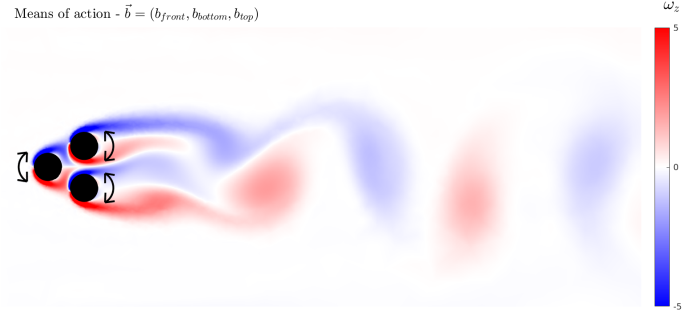
wind turbine

Means of action - $\vec{b} = (b_{front}, b_{bottom}, b_{top})$



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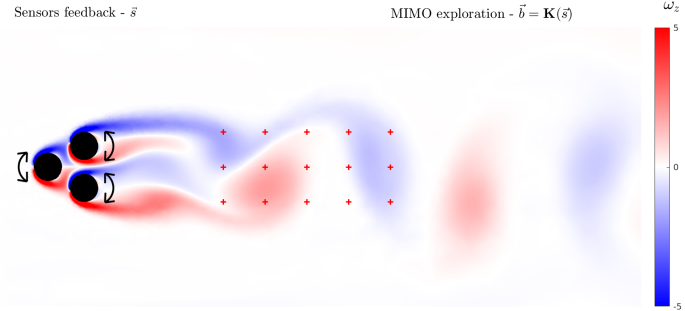

Marek Morzynski
DNS
Finite Elements Method
8633 vertices
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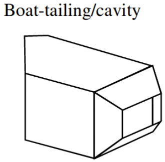

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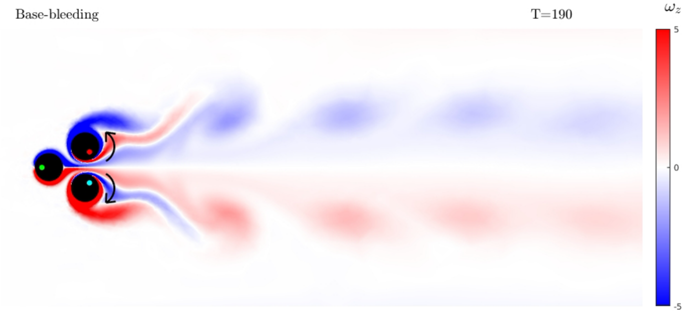

Splitter plate

The fluidic pinball - a nonlinear system for control benchmark

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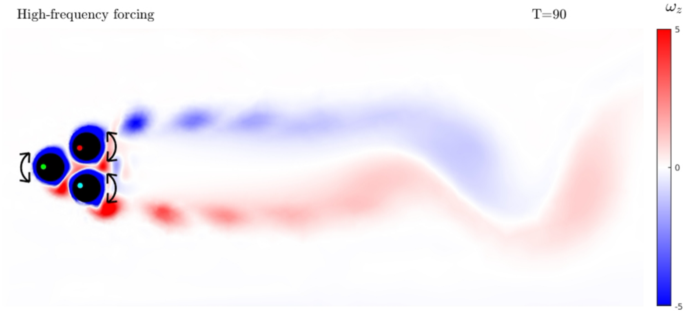
wind turbine



Frequency crosstalk!

The fluidic pinball - a nonlinear system for control benchmark

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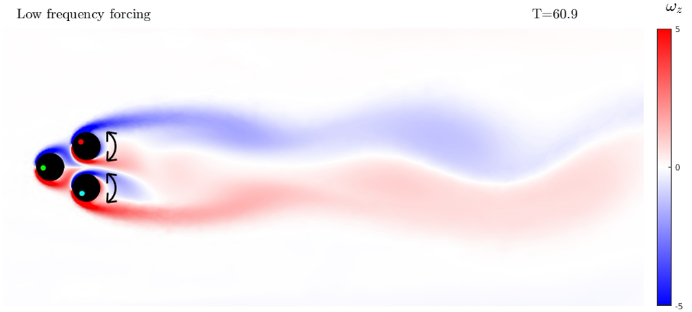
airborne transport

wind turbine



Frequency crosstalk!

The fluidic pinball - a nonlinear system for control benchmark

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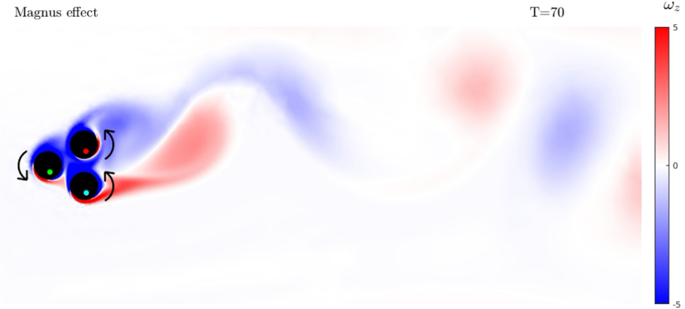
airborne transport

wind turbine



Alcyone

The fluidic pinball - a nonlinear system for control benchmark

ground transport

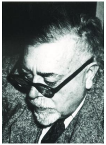
airborne transport

wind turbine

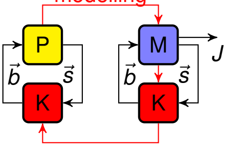
Alcyone

Control theory

Model-Based Control



Norbert Wiener

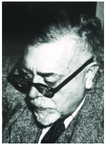


$$\frac{d\vec{a}}{dt} = F(\vec{a}, \vec{b})$$
$$\vec{s} = G(\vec{a}, \vec{b})$$
$$\vec{b} = K(\vec{s})$$

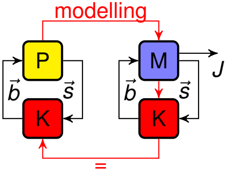
F : dynamical model of the plant (P)

Control theory

Model-Based Control



Norbert Wiener



$$\frac{d\vec{a}}{dt} = F(\vec{a}, \vec{b})$$
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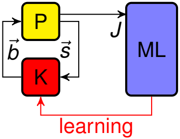
F : dynamical model of the plant (P)

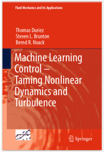
Artificial Intelligence Control

Control problem as a regression problem

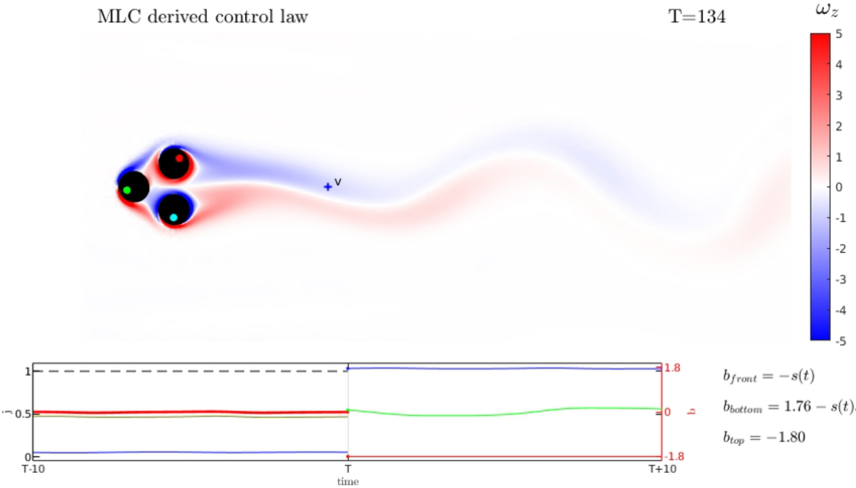


$$K^* = \mathrm{argmin\ J(K)}$$

T. Duriez,
S. Brunton,
B.R. Noack.
Springer, 2016.



Results of AIC



$b_{front} = -s(t)$

$b_{bottom} = 1.76 - s(t)s(t-1)$

$b_{top} = -1.80$

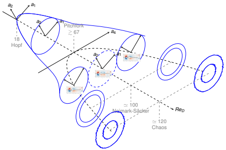
46.0% net drag power saving!

AIC = boat-tailing + phasor control

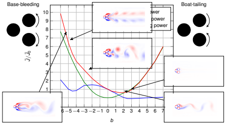
100 indivuals x 10 generations = **1000 evaluations!**

Summary and related works

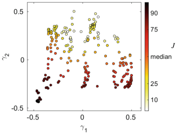
Bifurcation Diagram

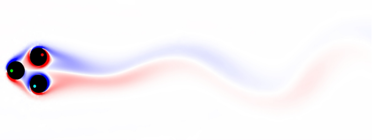


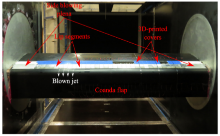
Open-loop study

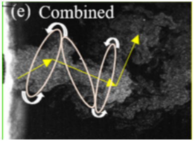


ML acceleration









LAMIH, Valencienne

Camilla Chovet, Laurent Keirsbulck

TU Braunschweig

Richard Seeman

HIT, Shenzhen

Yu Zhou

Thank you for your attention!
-
Questions?

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